ICHTHYOLOGY.—*Description of a new sandfish,* Kraemeria sexradiata, *from Japan, with special reference to its osteology.*[1]

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The sandfishes referred to the genus *Kraemeria* are inhabitants in the sandy shallow waters of the tropical Pacific and are by no means familiar even to ichthyologists. Remarkably enough, the members of this inconspicuous little group, attaining about 40 mm in total length, appear to exhibit a high endemism, and no one has found them before in the Japanese area.

Although the genus *Kraemeria* has been included in the family Trichonotidae or Gobiidae or sometimes placed in the independent family Kraemeriidae, their systematic position was in a state of confusion until Gosline's (1955) paper placed the family Kraemeriidae in the suborder Gobioidei based upon the results of his osteological studies.

The recent expedition to the Amami Islands, Kagoshima Prefecture, greatly augmented our limited knowledge of the ichthyological fauna of the southernmost district of Japan. Among a number of fishes collected, there were three specimens of the genus *Kraemeria* possessing sufficient distinctive characters to warrant the erection of a new species. The descriptions presented below are based on the material obtained from the sandy tide pools at Ankyaba and Usyuku, Amami Oshima, the largest island of Amami Islands.

In order to make a comparison of osteological features of the species with those of a known species, *K. samoensis*, a study of the bones of the present new species was undertaken. Counts and measurements of the bodily parts were made according to standard practice as outlined by Matsubara (1955, pp. 60–69). In the osteological examination the skeletal elements were stained with alizarin red and cleared with potassium hydroxide and glycerol.

Kraemeria sexradiata, n. sp. (Fig. 1)

Suna-haze (new Japanese name)

Holotype.—MIKU (Marine Biological Institute of Kyoto University) no. 1744, a mature male specimen, 33.0 mm in standard length (38.0 mm in total length), collected in the tide pool of Usyuku, Amami Oshima, on July 10, 1958.

Paratypes.—2 specimens, MIKU no. 1745, 30.2 and 30.5 mm (36.5 and 36.0 mm), collected in the tide pool of Ankyaba, on June 30, 1958.

Diagnosis.—K. sexradiata is a dwarf species, full-grown ova are found in a small female measuring 36.0 mm in total length. The body is slender and compressed laterally. The eye is very small. The lower jaw strongly projects far beyond the upper jaw. The pectoral fin consists of 6 rays, the lower 5 are branched. Scalloped flaps on the lower edge of the gill-cover number 3 to 5. In the fresh condition prior to preservation, the body is transparent. Counts and proportional measurements of bodily parts of types are shown in Table 1.

Table 1.—Counts and Proportional Measurements in Types of Kraemeria sexradiata

Items	Holotype	Paratypes	
Standard length in mm	33.0	30.5	30.2
Dorsal fin	V, 14	V, 14	V, 14
Anal fin	I, 13	I, 13	I, 13
Pectoral fin	6	6	6
Ventral fin	I, 5	I, 5	I, 5
Gill-rakers	9	—	9
Vertebrae	—	—	26
Sex	male	female	male
In standard length:			
Head length	4.1	3.8	3.8
Depth of body	8.5	6.2	8.6
Predorsal distance	3.1	3.2	3.1
Preanal distance	1.8	1.8	1.8
Length of pectoral fin	12.2	11.7	12.1
Depth of caudal peduncle	16.5	15.3	15.1
Length of caudal peduncle	16.5	16.9	16.8
In head length:			
Snout	6.7	6.7	6.7
Diameter of eye	26.7	26.7	26.7
Interorbital width	20.0	20.0	20.0
Length of upper jaw	3.8	4.0	4.2
Length of lower jaw	2.7	2.7	2.7

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Description of the holotype.—Body slender and compressed laterally, without scales. Head rather broad, about twice as wide as body. Opercle relatively large and the lower edge armed with 5 scalloped flaps. Posterior margin of membranous gill-cover extending over base of pectoral. A series of minute sensory papillae present along lower edge of preopercle, upper lip fold, and mandibular fold. Small nasal tube midway between tip of snout and eye. Eye very small. Mouth moderately large and obliquely directed. Lower jaw projecting far beyond tip of upper jaw when mouth is closed. Gill-membranes extend forward and narrowly joined to isthmus before a vertical through posterior margin of preopercle. Nine gill-rakers on ceratobranchial bone of first gill-arch, but no rakers on epibranchial and hypobranchial. No gill-rakers on other gill-arches. Pseudobranchae absent. Branchiostegal rays slender and 5 in number. Small conical teeth closely set on both upper and lower jaws, slightly curved, directed inward.

Dorsal fin consisting of 5 anterior spines and 14 soft rays, the posteriormost one bilobed. First dorsal spine originating above a vertical through posterior end of pectoral. Anal fin with 1 spine and 13 soft rays, the last one bilobed. Anal spine arises below membrane between second and third soft dorsal rays. Pectoral fin rays 6, all branched except the uppermost simple one. Pelvic fin with 1 spine and 5 branched soft rays, inserted below a vertical through posterior margin of opercle. Caudal fin 6 + 7 + 6 + 6.

Anal papilla slender, the posterior tip pointed.

In fresh condition prior to preservation body and fins transparent.

Description of paratypes.—The systematic characters of paratypes generally agree with those of the holotype except for scalloped flaps on the lower edge of the opercle, the flaps being 3 in one specimen and 4 in the other.

Remarks.—In some characters this new species closely resembles *K. cunicularia* Rofen but differs in having 6 pectoral rays (8 or 9 in *cunicularia*) and slender anal papilla with pointed posterior tip (flat anal papilla with notched posterior tip). Compared with the other species, *K. nudnum*, *K. sexradiata* is seen to differ in the fewer number of pectoral fin rays, 6 as against 8 (Regan, 1908, p. 246), and in having the scalloped flaps on the opercle (3–5 versus none).

Although Rofen (1955, p. 182) utilized the number of scalloped flaps on the lower edge of the opercle as an important character in distinguishing the species of this group, our specimens show a rather extensive variation in this character as aforementioned.

Name.—*K. sexradiata* is named in reference to the six pectoral rays of this fish. The Japanese name Suna-haze means sand-goby, in reference to its habitat.

OSTEOLOGY

In this section the skeletal system of *K. sexradiata* is described based upon the dissection of a specimen, 30.2 mm in standard length.

Jaws (Fig. 2, A).—The upper jaw consists of a premaxillary and maxillary. There is no supramaxillary. The premaxillary is a stout bar forming the anterior half of the upper edge of the gape, and armed with about 20 small conical teeth directed slightly inward. The maxillary is a well ossified curved bone overlying the dorsal surface of the premaxillary. The posterior end reaches to the lower prong of the dentary.

The lower jaw consists of a dentary, articular and angular. The dentary is the largest bone, bearing about 23 small conical teeth on the upper surface. At the anterior end the bone strongly projects downward. Posteriorly the dentary is bifurcated, the lower prong is longer than the upper one. The articular is a slender forked bone attaching to the posterior border of the dentary

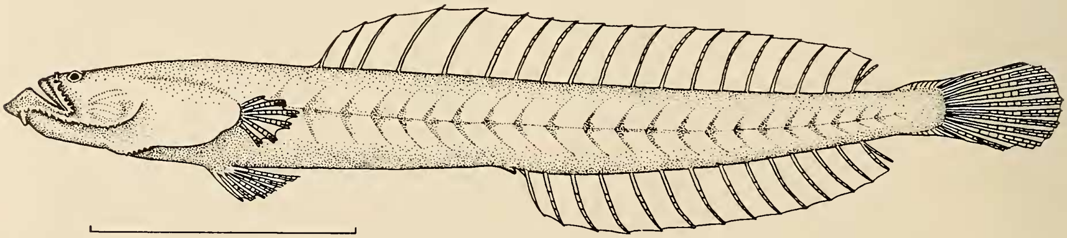

FIG. 1.—Lateral aspect of holotype of *Kraemeria sexradiata*, n. sp. Scale bar indicates 10 mm.

and abuts on the condyle of quadrate posteriorly. The lower wing of the bone becomes slenderer anteriorly and reaches to below the middle of dentary. The angular is a small heavy bone lying on the posterior end of the articular.

Suspensorium (Fig. 2, A).—The hyomandibular is roughly triangular in shape. Its dorsal border articulates along the ventrolateral margin of the pterotic. Posteriorly it articulates with the opercle by a small condyle. Anterior to the hyomandibular there extends a slender metapterygoid. The quadrate is a relatively large bone, bearing 3 projections. The first projection on the dorsal surface abuts against the pterygoid. The second one on the dorsoposterior edge meets the anterior end of the metapterygoid, and the last one on the posterior edge extends posteriorly along the dorsal border of the preopercle. The bone bears a heavily ossified condyle at its ventral corner for the articulation of the articular of the mandible. It is a remarkable fact that there is a broad interosseous space between the

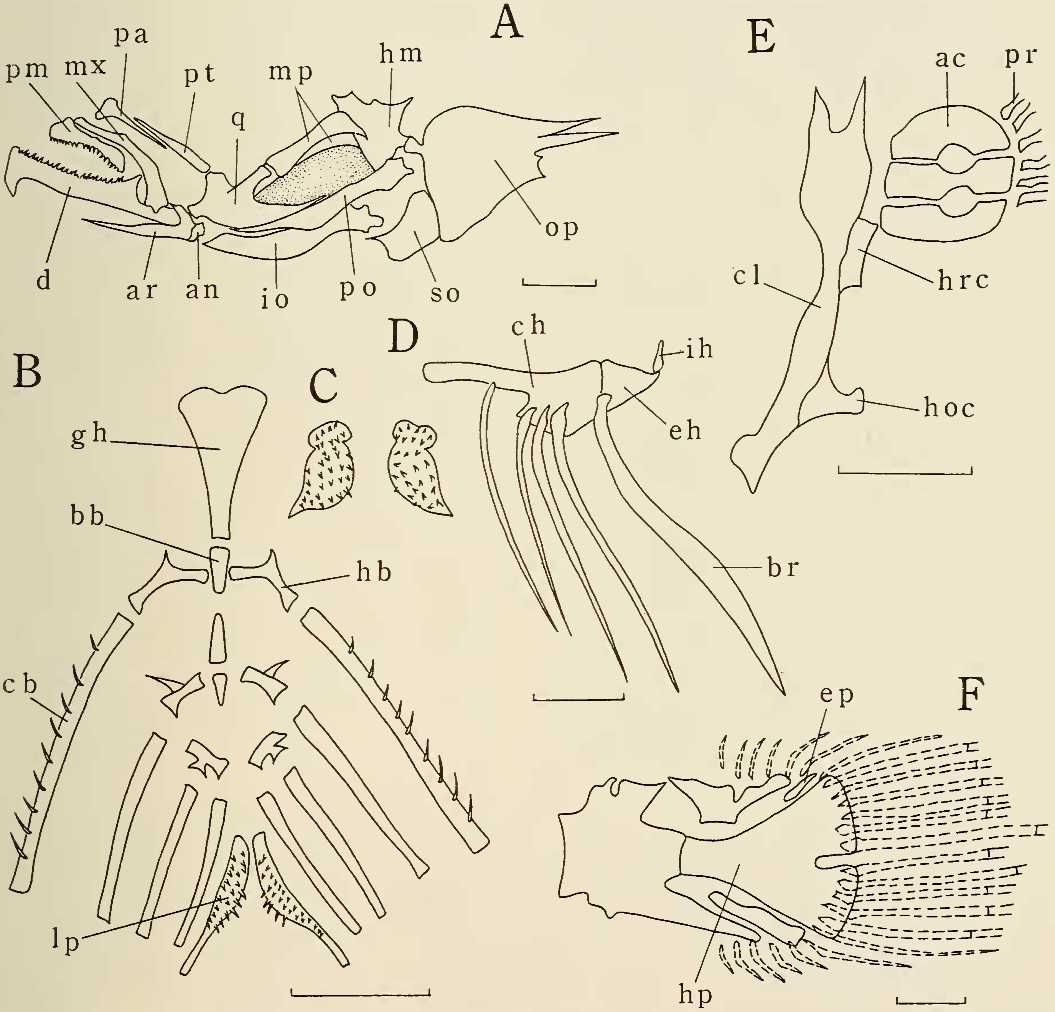

FIG. 2.—Lateral aspects of jaws, suspensorium (A), lower half of branchial arches (B), upper pharyngeal teeth (C), hyoid arch (D), shoulder girdle (E), and caudal skeletons (F) of *K. sexradiata*. (Each sale bar indicates 1 mm. *ac*, actinost; *an*, angular; *ar*, articular; *bb*, basibranchial; *br*, branchiostegal ray; *cb*, ceratobranchial; *ch*, ceratohyal; *cl*, clavicle; *d*, dentary; *eh*, epihyal; *ep*, epural; *gh*, glossohyal; *hb*, hypobranchial; *hm*, hyomandibular; *hoc*, hypocoracoid; *hp*, hypural plate; *hrc*, hypercoracoid; *ih*, interhyal; *io*, interopercle; *lp*, lower pharyngeal; *mp*, metapterygoid; *mx*, maxillary; *op*, opercle; *pa*, palatine; *pm*, premaxillary; *po*, preopercle; *pr*, pectoral fin ray; *pt*, pterygoid; *q*, quadrate; *so*, subopercle.)

hyomandibular - metapterygoid - quadrate strut and the preopercle (dotted area in Fig. 2, A).

Symplectic and mesopterygoid could not be detected, although it is difficult to manifest the absence of these bones.

The pterygoid is a thin, slender, rodlike bone lying between the quadrate and the palatine. Anteriorly it overlies the posterior portion of the palatine. The palatine is a small and edentulous T-shaped bone. Its dorsoanterior condyle articulates with the ethmoid region of the cranium with an intervention of the cartilagenous band.

Opercular series (Fig. 2, A).—All four opercular elements are present. The preopercle is a slender bone tapering anteriorly. The anterior half of it abuts against the ventral border of the quadrate. Dorsally it meets the ventroposterior border of the hyomandibular. The opercle is the largest bone among the opercular series. On the anterior edge, it bears a small condyle for the articulation of the hyomandibular. Posteriorly it is bifurcated into two sharp projections. The subopercle is quadrant in shape, and lies between the opercle and the interopercle. The interopercle, resembling the preopercle in shape, is attached to the lower edge of the preopercle.

Hyoid arch (Fig. 2, D).—The interhyal is a small bone, rodlike in shape, and capped with cartilagenous band at each end. The upper end of the bone is inserted on the proximal side of the juncture between the hyomandibular and the preopercle, and the lower end is attached to the dorsoposterior end of the epihyal. The epihyal is a flat, nearly triangular bone. The ceratohyal is a well ossified bone. The anterior half is slender, but the posterior half is abruptly expanded, being nearly as wide as long and about three times wider than the anterior half. The posterior end is sturdily joined with the epihyal. The hypohyal is not discernible.

There are 5 long branchiostegal rays, the last of which articulates with the junction between the epihyal and ceratohyal. Another 4 are set on the ceratohyal, the anteriormost one of which is attached to the slender portion of the bone and widely separated from the other 3 which are attached to the wider section.

The glossohyal is edentulous. It is a flat, fanshaped bone having a shallow notch at the tip (Fig. 2, B, *gh*). Posteriorly it articulates with the first basibranchial.

Branchial arch (Fig. 2, B).—The branchial apparatus consists of five branchial arches diminishing in size posteriorly. The median floor of the arches is composed of 3 basibranchials which lie longitudinally behind the glossohyal. All bones are rodlike in shape. There are hypobranchials on the first three branchial arches. The hypobranchial of the first arch is a slender bone with a projection at the anterior bend, and meets the first basibranchial. That of the second arch is similar to the first bone in shape, but about half as long as the first one. The third one is modified into a small tridentate bone. There are five slender ceratobranchials decreasing in length posteriorly. Only the first ceratobranchial is armed with a single row of short gill-rakers. The fifth one is modified into the lower pharyngeal bone bearing three rows of small conical teeth, apparently separated from the fellow of the opposite side (Fig. 2, B, *lp*).

Epibranchials are present on the first three arches. Since all of these bones are not well ossified, their detailed structures are obscure. The upper pharyngeal teeth are confined to a small patch on bony plate extending on the third and fourth branchial arches. The plates on two sides are not fused together along the median line (Fig. 2, C).

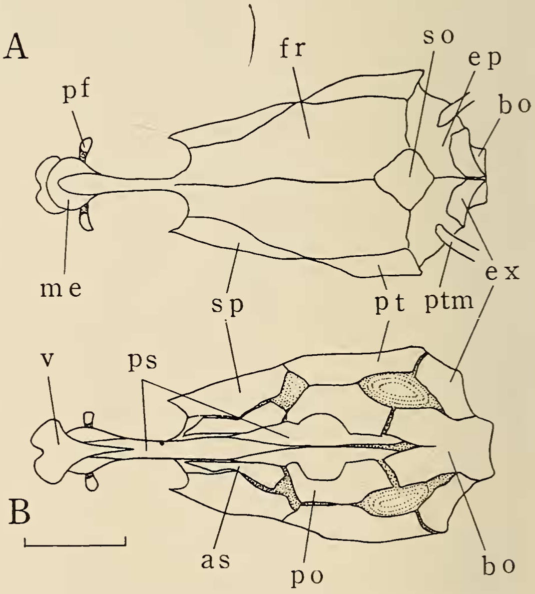

Fig. 3.—Cranium of *K. sexradiata*: (A) Dorsal aspect and (B) ventral aspect. (Scale bar indicates 1 mm. *as*, alisphenoid; *bo*, basioccipital; *ep*, epiotic; *ex*, exoccipital; *fr*, frontal; *me*, mesethmoid; *pf*, prefrontal; *po*, prootic; *ps*, parasphenoid; *pt*, pterotic; *ptm*, posttemporal; *so*, supraoccipital; *sp*, sphenotic; *v*, vomer.

Cranium.—On the dorsal aspect (Fig. 3, A), the anterior corner of the cranium is occupied with an unpaired thin bone which is thought to be mesethmoid. Anteriorly it is broadened and extends ventroanteriorly to the dorsal surface of the vomer.

The prefrontals are merely small rodlike bones on the lateral edges of the mesethmoid and not joined directly with the mesethmoid, but attached with the latter by an intervention to the cartilagenous patch.

The frontals are the largest flat bones covering a vast part of the top of the cranium. At the interorbital region, they are abruptly constricted in width and so securely fused together along the midline that the suture is not apparent on this region (Fig. 3, A, *fr*). The anterior end of the fused frontal overlies the mesethmoid. Behind the orbit each frontal expands and abuts against the sphenotic and pterotic laterally, and against the supraoccipital and epiotic posteriorly.

The dorsal surface of the sphenotic is narrowly exposed along the lateral border of the frontal.

The pterotics are slender bones lying behind the sphenotics. Each bone meets the frontal laterally and epiotic posteriorly. The latero-posterior end of the bone is pointed.

The parietals appear to be absent.

The supraoccipital is a median dorsal bone extending between the frontals and also epiotics. Its rhombic dorsal portion is well ossified. It is separated from the exoccipital by an intervention of the epiotic.

The epiotics form a portion of posterolateral edge of the cranium. The dorsoposterior part of each bone receives the anterior end of the posttemporal. The bone is bounded with the pterotic and frontal anteriorly and with the exoccipital posteriorly. Mesially it meets the counterpart of the opposite side at the midline, and separates the supraoccipital from the exoccipital.

The exoccipitals contribute to form most of the posterior surface of the cranium. They meet along the dorsal median line. Dorsally the bone slightly overlies the epiotic. In the ventral aspect they curve ventroanteriorly to meet the dorsoposterior edge of the basioccipital.

On the ventral aspect (Fig. 3, B), the vomer forms the anterior corner of the cranium. It is a fanlike bone with a rather deep notch at the tip. Posteriorly it becomes abruptly narrower, sliding under surface of the anterior part of the parasphenoid. No teeth could be found on the vomer.

The parasphenoid, running along the midline of the ventral surface of the cranium, is a long narrow bone. From near the bilobed posterior end over the basioccipital the bone widens anteriorly and sends the lateral wings on both sides extending toward the prootics. Then it becomes narrow between the orbits and the anterior end is inserted between the vomer and the ethmoid cartilage.

The median basioccipital forms the posterior end of the ventral surface of the brain case. Anteriorly, it is deeply excavated and each arm attaches to the parasphenoid and prootic. Posteriorly it is thickened to form a condyle for the articulation of the atlas.

There is no opisthotic. The portion of the otic bulla is covered by the interosseous membrane (posterior dotted area in Fig. 3, B).

Each prootic forms a suture for the alisphenoid anteriorly, for the parasphenoid ventrally, for the pterotic dorsally, and for the basioccipital posteriorly.

The alisphenoids are slender elements and they are united dorsoanteriorly under the frontals.

There is no basisphenoid.

Shoulder girdle (Fig. 2, E).—Although almost all the skeletal elements are present in the shoulder girdle, the ossification is imperfect. The posttemporal, hypercoracoid, and hypocoracoid are much reduced in size. The posttemporal is a simple strut and is bound tightly to the upper edge of the epiotic. Ventrally it articulates with the dorsal edge of the supraclavicle which is slender in shape.

The dorsal extremity of the clavicle is shallowly furcated. It extends ventroanteriorly and is forklike in general appearance.

The hypercoracoid, rectangular in shape, lies behind the clavicle. The dorsoposterior edge meets the lowermost actinost.

The hypocoracoid is roughly triangular in shape and attached to the posterior edge of the lower bend of the clavicle. It is well separated from both the hypercoracoid and actinosts.

There are 3 large actinosts with a large foramen between each of them, all of them lying a short distance behind upper portion of the clavicle (Fig. 2, E, *ac*).

No postclavicle could be recognized.

Caudal skeletons (Fig. 2, F).—All hypural bones are fused together and modified into a fan-like plate (Fig. 2, F, *hp*). It is deeply excavated at the middle of the posterior border. The suture between the urostyle and hypural plate is obscure. There is a single epural above the upper border of the hypural fan. The neural process of the urostyle is separated from the hypural plate and directed upward. There is a splint-like bone between the hypural plate and the last haemal spine. The last two vertebrae contribute to support the caudal fin rays.

There are 26 vertebrae including hypural plate.

CONSIDERATIONS AND CONCLUSION

In general, the osteological features of *K. sexradiata* agree with those of *K. samoensis* as given by Gosline (1955, pp. 158–170), with the exception of some minor points. The differences between them are as follows: (1) Gosline drew a large symplectic bone below the metapterygoid, but so far as our observations go, the bone recognized by him as symplectic appears to be a bony shelf extending from the metapterygoid. Evidence that the interhyal bone articulates with the juncture between the preopercle and the posterior end of the quadrate strongly suggests that the reduced symplectic bone, if present, may lie near this area. (2) Although Gosline stated that the alisphenoid appears to be lacking, in our specimen this paired bone is recognizable in front of the prootic. (3) Lower pharyngeals are evidently separated in our species versus they are entirely fused without suture in *samoensis*. That the individual bones of the skeletal system in such small fishes as *Kraemeria* are not sufficiently demarcated owing to unsatisfactory ossification might explain these differences.

Koumans (1931, p. 14) included the Psammichthyidae (=Kraemeriidae) in the order Gobioidea. Schultz (1941, p. 269) stated that *Kraemeria* has features that resemble the trichonotids more than the gobiids.

Gosline (1955, p. 165) placed *Kraemeria* in a distinct family Kraemeriidae and assigned the latter to the suborder Gobioidei on the basis of the following features: (1) the parietals are absent, (2) the branchiostegal rays are 5 in number, the first one of which is far separated from the others, (3) there is a broad interosseous space between the metapterygoid and preopercle, and (4) the hypural plate bears detached splint-like bone on both dorsal and ventral sides. He concluded that these features of *Kraemeria* agree with those of gobioid fishes but disagree with those of both blennid and trichonotid fishes.

Results of our osteological observation, as well as such peculiar external features as steeply projected lower jaw and scaleless body would be sufficient to justify the retention of *Kraemeria* in a separate family. On the other hand, the fishes of the genus *Kraemeria* seem to be closely related, in general physiognomy, to those of the family Trichonotidae. But, at the present, there is no adequate information on the osteological features of the trichonotid fishes, which will enable us to compare both groups. Accordingly, the decision whether the family Kraemeriidae belongs to the suborder Gobioidei or other separate suborder, should be withheld until such a time as more information becomes available concerning the anatomical features of the trichonotid fishes, although the fact that the pelvic fins are united for one-fifth the length of inner rays by a membrane in *Kraemeria tongaensis* and for their full length in *Gobitrichinotus radiocularis* (Rofen, 1958, p. 182), both of which are referred to Kraemeriidae, may support Gosline's conception concerning the allocation of Kraemeriidae to the gobioid group.

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